REPORT

ON

ENERGY MANAGEMENT/ CONSULTANCY STUDIES

FOR

ELECTRIC UTILITIES

Presented by :

TATA ENERGY RESEARCH INSTITUTE
Krupa, 50/7, Palace Road, Bangalore 56 052

H.O

Darbari Seth Block, India Habitat Centre,
Lodi Road, New Delhi 110 003

JULY, 1997

ENERGY MANAGEMENT SYSTEMS
SERVICES FOR ELECTRIC UTILITIES/ELECTRICITY BOARDS

CONTENTS

ENERGY MANAGEMENT SYSTEMS / CONSULTANCY STUDIES
FOR
ELECTRIC UTILITIES/ELECTRICITY BOARDS

1.0 ENERGY AUDITING OF UTILITY DISTRIBUTION SYSTEMS. LOSS REDUCTION AND SUPPLY QUALITY IMPROVEMENT

Scope of study covered : Field measurements/Energy Auditing
Loss Reduction & Voltage improvement
System Improvement measures/modifications(short/long term)
Techno-economics and reporting

System covered 11 kV- Primary distribution System
415 V LT distribution System
(Any other desired system voltage level)

Approach Field power measurements and energy auditing are carried out on the system Data pertaining to the system maps, line and load data is collected System is simulated and the software is run to obtain the voltages, currents, etc These are compared against the measured parameters The cost benefit analysis of the system modifications is carried out After the proposed measures are implemented on feeders, measurements are carried out again to check the returns

Benefits Creation of system data base, System power flow study, Simulation of system improvements, Cost-benefit analysis, Field implementation, Practical field measurements before and after modifications to check loss reduction and improvement in voltages The study would quantify both the technical and non-technical losses

2.0 OPTIMAL CAPACITOR INSTALLATION ON DISTRIBUTION FEEDERS

Scope of study : Feeder data collection (of lines and loads)
Field Power and Energy measurements
Computation of Capacitor locations, sizes and switching times
Techno-economics

System Covered 11kV- Primary distribution feeders
LT 415 V feeders
or any other desired system voltage level

Approach Shunt Capacitors are the most economical and easy means of providing reactive compensation in the system By improving the system power factor there will be significant reduction in the power and energy savings However on any given feeder the number, sizes and locations of capacitors have to be properly chosen to yield maximum net annual savings

Based on the line and load data of the study feeder and the load variation, the Capacitor Optimisation program computes the optimal number, sizes and locations of shunt capacitors to be installed on the feeder for maximum benefit The objective function Rupees Net Annual Savings is maximised The cost of the capacitors, cost of power, cost of energy are also considered along with the power loss and energy loss reductions

Benefits Best capacitor installation scheme based on scientific and rigorous approach would be provided The practical field measurements would substantiate the savings envisaged

3.0 HARMONIC ANALYSIS ON DISTRIBUTION FEEDERS

Scope of study

Field Power and Harmonic measurements
Identification of predominant harmonics
Optimal Shunt Capacitor placement &
Design of harmonic filters

System Covered

11 kV- Primary feeders, 415 V LT system
or any other voltage level

Approach

Power-electronic loads, Arc furnace loads etc used in the industries generate harmonics Harmonics cause malfunctioning and excessive heating of equipment and as a result the equipment get derated Also the harmonics generated by an industrial load inject pollution into the utility supply system. Hence the utilities have to keep a check on this, just similar to power factor correction To avoid this, the harmonics have to be suitably filtered and the waveforms, both current and voltage have to be brought to near sinusoid

The system data is collected and the harmonic data is generated through practical measurements The monitoring has to be continuous over a minimum selected period and measured upto the 50th harmonic level The predominant harmonics are identified along with the THD levels for current and voltage

The reactive power requirements for the plant are assessed and capacitor sizes are calculated Based on the sizes of capacitors the shunt tuned filters are designed The frequency response plots indicate the suppression of harmonics in the system This is validated by the harmonic power measurements after the filter installation

Benefits

Harmonic pollution in utility supply systems is avoided Guidelines could be provided by utilities to industries to cheep check on their harmonic levels of loads

4.0 ASSESSMENT OF QUALITY OF POWER SUPPLY

Scope of Study : Power quality parameters - measurement
Statistical Evaluation

System Covered 11 kV Primary System and LT Systems

Approach Occurrence of transients/surges, swells, sags etc due to various loads can cause damage to costly equipment All these parameters can be monitored over a period of time and power quality assessment can be made based on the data collected.

Benefits Quality of power supply assessment is gaining a lot of importance world wide Many want these studies to be conducted now Quality assessment would enable trouble shooting and to decide and distinguish between the mal-operation/mal-functioning of the equipment and problems in power supply

5.0 RELAY CO-ORDINATION STUDIES ON POWER AND DISTRIBUTION SYSTEMS

Scope of study

Collection of system data, fault data
Study of present settings of relays
Conducting Relay and fuse co-ordination studies
Appropriate changes in settings

System Covered · Power and Distribution Systems

Approach

Over current relays and fuses are predominantly used in the distribution systems Distance relays are also used in power transmission systems Correct settings of relays is extremely important for the protection of the system and equipment

Relay co-ordination studies involve correction of settings in the relays by checking co-ordination of various protective devices

Benefits

Checking and correcting relay co-ordination in systems

6.0 GROUNDING STUDIES ON SYSTEMS

Scope of study Soil resistivity measurements
Design of ground mats
Measurement of earth resistance

System covered Substations, switch yards, etc

Approach Soil resistivity measurements are carried out at places where new switch yards are laid out and ground mats are planned Ground mat design is carried to limit earth resistance and to take care of the touch and step potentials Ground mat resistances are found out by measurements

Benefits . Easy and one point solution in designing and checking ground mats through practical measurements

7.0 POWER FLOW STUDIES AND STABILITY STUDIES ON POWER SYSTEMS

Scope of study : Conducting power flow studies on power systems and captive power plants

System covered : Interconnected power systems

Approach : The single line diagram, line and load data are collected from the utilities. Power flow studies are carried out for various scenario
After obtaining load flow, transient stability studies are carried out to find critical clearing times for breakers

Benefits : Power flow solution is obtained, losses are known, reactive power compensation is assessed and optimal operation is planned Critical clearing times of breakers are found and stability is checked

8.0 : **POWER AND ENERGY STUDIES ON CAPTIVE POWER PLANTS**

Scope of study : Power flow studies/optimal generation
Meeting critical loading of plants
Capacitor compensation studies
Stability studies
Islanding studies
Critical clearing times
Fault currents
Relay co-ordination
Transient torque studies
Motor starting studies

System Covered : Interconnected systems and captive power plants

Approach Using System simulation softwares various studies as indicated above are conducted after the system data is collected from the utilities

Benefits Complete studies on captive power plants This provides complete information on the design, operation and performance of the plants under contingencies

1.0 ENERGY AUDITING OF UTILITY DISTRIBUTION SYSTEMS. FOR LOSS REDUCTION AND SUPPLY QUALITY IMPROVEMENT

1.1 Scope of study covered

Field measurements/Energy Auditing
Loss Reduction & Voltage improvement
System Improvement measures/modifications(short/long term)
Techno-economics and reporting

1.2 System covered

11 kV- Primary distribution System
415 V LT distribution System (Any other desired system voltage level)
(study feeder wise or substation wise)

1.3 Approach

Field power measurements and energy auditing are carried out on the system. Data pertaining to the system maps, line and load data will be collected System is simulated and the software is run to obtain the voltages, currents, voltage drops, losses, etc These are compared against the measured parameters. The cost benefit analysis of the system modifications is carried out. After the proposed measures are implemented on feeders, measurements are carried out again to check the returns

1.4 Benefits

Creation of system data base, System power flow study, Simulation of system improvements, Cost-benefit analysis, Field implementation, Practical field measurements before and after modifications to check loss reduction and improvement in voltages The study would quantify both the technical and non-technical losses

1.5 Description

1.5.1 Introduction

The existing generating capacity in India is 80,000 MW and an amount of 1,41,000 MW would be added through privatisation etc by 2007 The existing per capita consumption per year is 275 kWh, a very low figure compared to 8,000-10,000 kWh in case of developing countries
The utilisation of electrical energy in India at various voltage levels is given below The break-up of power loss in those voltage levels is also shown

Voltage Level	% Energy Utilisation	% Loss
400 V	36	12
11 kV	33	9
33 kV & above	29	4

The transmission and distribution losses in the country are as high as 25% compared to a figure of 6 to 8% in advanced countries This is due to lack of systematic approach in planning, constructing and maintaining distribution

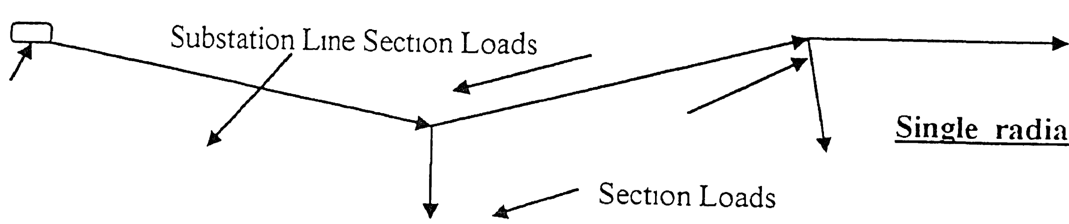
Some of the main reasons for high rate of losses are -

- Inadequate conductor size used for the distribution system
- Inadequate planning and improper layout of the system
- Substations far way from load centres
- Primary and secondary feeders, unreasonably lengthy and overloaded
- Uneconomical and uneven distribution of loads along feeders
- Improper voltage level and low power factor of the load
- Distribution transformers not located at load centres
- Under utilisation of distribution transformers
- Low power factor and inadequate reactive compensation
- Loose connection of HT lines
- Other commercial reasons like inaccurate billing, theft of energy, pilferage etc

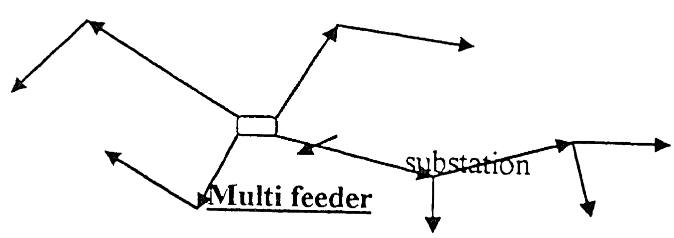
The economical voltage drop in the primary feeder should be 8 to 9 % If the voltage drop exceeds the above limit, then some of the effective corrective measures listed below can be applied for reducing the loss as well as for improving the system voltage

a) Power factor correction by installing capacitors
b) Re-routing of feeders so that extra length involved in extensions following zigzag path is almost eliminated
c) Transferring of loads from overloaded feeders to lightly loaded feeders
d) Augmentation of transformer capacity to cater to overloading
e) Increasing the size of the conductor to improve the tail end regulation(Re-conductoring)

1.5.2 Methodology : Study area is selected The area can be predominantly rural, urban or of a mix of different types of loads The study can cover the analysis feeder wise or can cover all the feeders pertaining to a substation for the study as shown below



Single radial Feeder



Multi feeder

The system single line diagram drawn to scale (preferably including the geographical information) is collected from the utility The information pertaining to the loads, lines, growth factor, diversity factor etc are also collected

Field power measurements are carried out to ascertain the exact loading at various locations on the feeder This would give information on the section voltages, currents, voltage drops, power losses, power factor etc

The line and load data along with the factors obtained from field measurements are also input to the software to simulate various system improvement measures that can be field implemented The techno-economics of these field implementations will be evaluated

Measurements are carried out again to check the benefits obtained on the system

(Table: Typical results of a KEB 11 kV distribution System feeder)

Sl No	Particulars	Original System	Modified System
1	Total Connected load (kVA)	1639	1639
2	Total Losses (kW)	80 12	53 0
3	Lowest Terminal Voltage(kV)	10 2	10 52
4	% Regulation	7 84	4 56
5	Savings in Losses(kW)		27 16
6	Cost of Modifications(Rs)		34,853/-
7	Cost of Energy Saved(Annual-Rs)		32,169/-
8	Pay-back period		1 08 years

1.5.3 Tools used : The following sophisticated tools will be made use of for the detailed energy study Power monitors, powerfactor meters, distribution system software for analysis

1.5.4 Ultimate benefits

- Improved quality and service for the consumers
- The system operation, control, monitoring and billing become mechanised and simple
- The system data collection helps in further system improvement

Direct benefits from the project:

- 20 -30 % saving in power
- Voltage within statutory limits
- Flattening of the load curve and reducing the peak demand
- Serving more number of consumers
- Deferred transformer capacity
- Voluntary load control by consumers through tariff modification

2.0 OPTIMAL CAPACITOR INSTALLATION ON DISTRIBUTION FEEDERS

2.1 Scope of study: Feeder data collection (of lines and loads)
Field Power and Energy measurements
Computation of Capacitor locations, sizes and switching times
Techno-economics

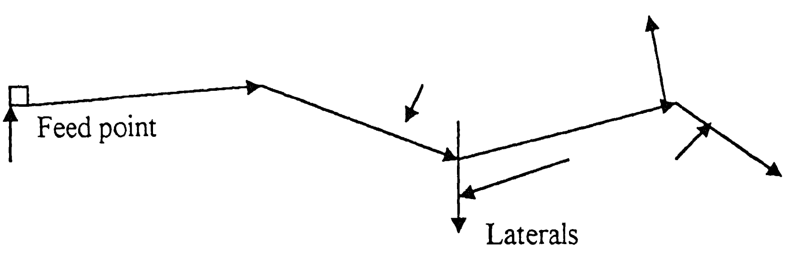
2.2 System Covered 11kV- Primary distribution feeders
LT 415 V feeders or any other desired system voltage level

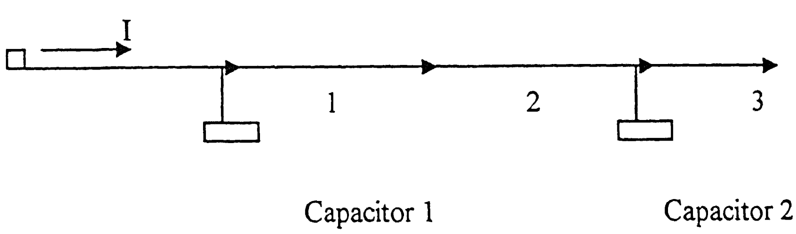
2.3 Approach Shunt Capacitors are the most economical and easy means of providing reactive compensation in the system By improving the system powerfactor there will be significant reduction in the power and energy savings However on any given feeder the number, sizes and locations of capacitors have to be properly chosen to yield maximum net annual savings

Based on the line and load data of the study feeder and the load variation, the Capacitor Optimisation program computes the optimal number, sizes and locations of shunt capacitors to be installed on the feeder for maximum benefit The objective function Rupees Net Annual Savings is maximised The cost of the capacitors, cost of power, cost of energy are also considered along with the power loss and energy loss reductions

2.4 Benefits Best capacitor installation scheme based on scientific and rigorous approach would be provided The practical field measurements would substantiate the savings envisaged

2.5 Description : main path





To achieve the maximum benefit at minimum cost through shunt compensation proper choice of number, size and location of shunt capacitors along the radial feeder becomes necessary In other words the net savings which is the difference between the maximum cost benefits achieved due to power and energy loss reduction and the cost of capacitors should be maximum for any particular system Also a distribution system which is adequately compensated for its full load conditions becomes over compensated during light load conditions resulting in not only over voltage problems but also reduced economic benefits due to over compensation Hence this also calls for optimising the switching time of the capacitor

Savings function

$$S = K_p L_p + K_e L_e - K_c \Sigma I_{ci}$$

where,

L_p is the peak power loss reduction
L_e is the energy loss reduction
I_{ci} per unit capacitor kVAr rating
K_p annual cost per unit of power loss(Rs /kW/Year)
K_e permit energy production cost(Rs /kWh)
K_c annual cost per unit of installed fixed capacitor(Rs /3ph kVAr/Year)

Data required for the study

Line data including conductor length, resistance and reactance for each length
kVA load at each section with power factor
System voltage
Load profile / Load duration curve
Cost factors

Basic Field measurements

Section voltages and currents
Loading of transformers and power factor

3.0 HARMONIC ANALYSIS ON DISTRIBUTION SYSTEMS

Scope of study : Field Power and Harmonic measurements
Identification of predominant harmonics
Optimal Shunt Capacitor placement &
Design of harmonic filters

System Covered : 11 kV- Primary feeders, 415 V LT system or any other voltage level

Approach

Power-electronic loads, Arc furnace loads etc used in the industries generate harmonics. Harmonics cause malfunctioning and excessive heating of equipment and as a result the equipment get derated Also the harmonics generated by an industrial load inject pollution into the utility supply system Hence the utilities have to keep a check on this, just similar to power factor correction To avoid this, the harmonics have to be suitably filtered and the waveforms, both current and voltage have to be brought to near sinusoid

The system data is collected and the harmonic data is generated through practical measurements The monitoring has to be continuous over a minimum selected period and measured upto the 50th harmonic level The predominant harmonics are identified along with the THD levels for current and voltage

The reactive power requirements for the plant are assessed and capacitor sizes are calculated Based on the sizes of capacitors the shunt tuned filters are designed The frequency response plots indicate the suppression of harmonics in the system This is validated by the harmonic power measurements after the filter installation

Benefits

Harmonic pollution in utility supply systems is avoided Guidelines could be provided by utilities to industries to keep check on their harmonic levels of loads

Description

Harmonics are voltage and current frequencies riding on top of normal voltage and current waveforms Current harmonics are usually induced on to the power line by non linear electronic equipment and systems which operate using switched mode power supplies that gulp current, distorting its waveform Voltage distortion typically results from current distortion reacting with system impedance These waveforms, usually lumped together as total harmonic distortion(THD) perform no useful work and can be a significant nuisance.

Harmonics can affect the performance of the motors and are both caused by and can interfere with the function of adjustable speed drives Harmonics also have raised concerns about excessive currents and heating in transformers and neutral conductors The following points address issues arising from harmonics

- The best method for dealing with harmonics is avoidance choose equipment and installation practices that minimise the level of harmonics in any one circuit or portion of a facility
- Harmonics increase heating in induction motors with a commensurate impact on expected motor life
- Harmonics problems are best mitigated to their source Harmonic traps and inductive chokes are two common methods
- Equipment or system performance problems caused by harmonics often appear at first to be equipment or control failures, making them more difficult to trouble shoot Good indicators of harmonic problems are (1) the problem is inexplicably confined to a certain area or circuit (2) abnormal behaviour happens only at certain times of the day, or at a particular interval or(3) the operating temperature of the transformers, motors, or wiring is inordinately high for the power they seem to deliver
- The addition of power factor correcting capacitors to a power system carrying harmonics can lead to "harmonic resonance" greatly increasing the amplitude and therefore the detrimental impact of the harmonics on motors and other equipment Under these circumstances, the capacitors must be carefully sized and possibly combined with the addition of a harmonic trap to eliminate resonance
- Although adjustable speed drives are known to be sources of harmonics, their electronics can also be sensitive to power distortion, improper grounding and voltage transients
- The most common sources of harmonics are computers, electronic equipment using switched mode power supplies, adjustable speed drives and high efficiency electronic light ballasts

Harmonic waveforms are characterised by their amplitude and number Harmonics are created by switching loads(also called non linear loads because current does not vary smoothly with voltage as with simple resistive and reactive loads) Each time these loads switch current on and off a current pulse is created

The following harmonic limits have been adopted in India to meet the performance requirement for HVDC systems

Individual harmonic voltage	= 1 %
THD	= 4 %

4.0 ASSESSMENT OF QUALITY OF POWER SUPPLY

Scope of Study : Power quality parameters - measurement
Statistical Evaluation

System Covered 11 kV Primary System and LT Systems

Approach Occurrence of transients/surges, swells, sags etc due to various loads can cause damage to costly equipment All these parameters can be monitored over a period ot time and power quality assessment can be made based on the data collected.

Benefits . Quality of power supply assessment is gaining a lot of importance world wide. Many want these studies conducted now Quality assessment would enable trouble shooting and to decide and distinguish between the mal operation/malfunctioning of the equipment and problems in power supply.

Description : Transient power problems are probably the most indiscriminate of all power quality problems they strike all customers whether industrial, commercial or residential Transient power problems are characterised by their relatively short duration - usually less than 20 cycles(300 milli seconds) and often less than one cycle(16 milli seconds) which can make them very difficult to isolate and eliminate. A partial listing of potential transient power problems includes

Voltage sags: voltage amplitude drops below normal for a few cycles
Temporary overvoltage: longer term voltage anomalies
Under/over frequency too many or too few cycles per second
Voltage spikes : abrupt spikes caused by switching or lightning
Ringing transients high frequency, damping sinusoids that boost voltage often caused by switching of powerfactor correcting capacitors
voltage unbalance small differences in phase voltages that can have significant effects on motors

5.0 RELAY CO-ORDINATION STUDIES ON POWER AND DISTRIBUTION SYSTEMS

Scope of study

Collection of system data, fault data
Study of present settings of relays
Conducting Relay and fuse co-ordination studies
Appropriate changes in settings

System Covered

Power and Distribution Systems

Approach

Over current relays and fuses are predominantly used in the distribution systems Distance relays are also used in power transmission systems Correct settings of relays is extremely important for the protection of the system and equipment

Relay co-ordination studies involve correction of settings in the relays by checking co-ordination of various protective devices

Benefits

Checking and correcting relay co-ordination in systems

Description

It is the objective of the protective system to isolate the faulty section, so that system is affected to the least extent Hence proper co-ordination of the protective devices is essential , which means that these devices should clear the fault in a pre-set sequence For this co-ordination additional system data is also essential

Protective Devices The following devices are provided in the system

Device	Purpose/application	Remarks
Isolating Switches	for maintenance purpose	rated for duty at normal currents-can not be operated for protection purposes
Off-load devices-contactors	do	do
Fuses	------	Protection
Non-delay fuses		used along with MCCBs and always with MCBs of large rating
Time-delay fuses		for over load protection alongwith fault protective equipment
LV-fuses of HRC type		for specific prospective short circuit currents-

		100 kA Current limiting action is given as let through currents Fuse characteristics are total clearance and minimum melting time for any fault current
High voltage fuses cutouts		no current limiting capacity and have limited fault handling capacity suitable mainly for distribution systems
Direct acting devices-MCCBs	------	Protection-direct acting
Circuit Breakers	------	Indirect acting-through relays
LV-Breakers		use air as interrupting medium-limited capacity ones are available with moulded case feature(MCCB) These breakers are thermal-magnetic, fully magnetic or integrally fused type, where the magnetic unit provides the capacity to clear faults of lower order and fuses backup for severe faults
HV breakers		use oil, SF6 , vacuum, air-blast

6.0 GROUNDING STUDIES ON SYSTEMS

Scope of study Soil resistivity measurements
Design of ground mats
Measurement of earth resistance

System covered Substations, switch yards, etc

Approach : Soil resistivity measurements are carried out at places where new switch yards are laid out and ground mats are planned Ground mat design is carried to limit earth resistance and to take care of the touch and step potentials Ground mat resistances are found out by measurements

Benefits : Easy and one point solution in designing and checking ground mats through practical measurements

Description : In many electrical systems, it is necessary to have in the ground installed an electrode or a system of electrodes which serves as an electrical connection from an electric circuit in the system to the earth Such a connection is ordinarily referred to as a 'ground ' A grounding electrode is a conductor or other metallic object embedded in the earth, used for maintaining ground potential on conductors connected to it and for dissipating into the earth, current conducted to it Some of the grounding electrodes are

(a) driven rods
(b) buried conductors
(c) buried plates
(d) incidental grounding electrodes such as water pipes, penstocks, draft tubes etc

A ground mat is a metallic mat so constructed and connected to the grounding system as to provide an operating area that is at the same potential as all nearby grounded structures and equipment

Measurement of Earth Resistance The basic measurements normally used consists essentially of passing a current through the station ground via a ground electrode or probe remote from the station and measuring the voltage produced between the station ground and the surface of the ground at a remote area

SL No	Name of the Consultancy study	Objective	System/area covered	Potential Energy Savings	Field meas / Computation	Resources available	Hardware required	Software required P-to procure D-to develop
1	Energy Auditing of Utility Distribution Systems	Loss reduction, Voltage Improvement	11 kV & LT dist Systems Single or multi feeders	20% to 40%	Power & Energy parameters Techno-econmics	Power & energy monitors	Nil	System Analysis software [P]
2	Optimal Capacitor Compensation	To arrive at Optimal number Sizes & locations of capacitors	11 kV and LT feeders	10% to 30%	Power & energy parameters	Power & Energy Monitors	Nil	Capacitor Placement Software[P]
3	Harmonic Analysis	To identify predominant harmonics and magnitudes & suggest filters	Any system level(Mainly below 11 kV)	5% to 25%	Power, energy and harmonic parameters Continuous monitoring & Threshold setting	Power and Energy Monitors Limited Harmonics facility	Sophisticated Harmonic Analyser	Filter Design software
4	Supply Quality Assessment	To log the system disturbances	Mainly LT and below 11 kV systems	5 to 15% reliability & operation improved	Disturbance monitoring	Very limited facility	Disturbance Monitor	Statistical evaluation of logged data[D]
5	Relay Co-ordination	To check and correct Relay co-ordination on electrical systems	LT, Primary distribution and sub-transmission systems	5 to 15% reliability & operation improved	System and fault data, relay data collection	Power monitoring	Nil	Relay co-ordination software[P]
6	Grounding Consultancy Studies	To measure soil resistivity and resistance of earth mats, design mats and check resistance	Substation/ power station switch yards and equipment	5 to 15% reliability & operation improved	Measure soil resistivity and measure earth resistance	Nil	Earth Tester Kit	Earthing design software[P]
7	Powerflow studies	To compute voltages, currents and losses on power systems, evaluate stability of generators	Interconnected power systems	reliability & operation improved	Power measurement at necessary locations in the system and computations using software	Power monitoring at desired locations	Nil	Powerflow/stability software[P]
8	Energy studies on Captive Power plants	To check power flow, stability, islanding studies, protection studies under different contingencies	Captive Power Plants at industrial sites	reliability & operation improved	Power Measurements and computations using software	Power monitoring equipment	Nil	Powerflow/ stability software[P]

Model draft letter

7th July 1997

To,

Dear Sir,

Sub: Energy Auditing of Electrical Power Distribution Systems

TERI, Bangalore centre has vast experience in implementing detailed energy audits/conservation projects and has a core group of professionals trained in modern energy efficiency concepts and practices TERI has carried out more than 200 assignments in various industries GTZ, Germany provides active co-operation for specific energy conservation programmes by TERI

As you are aware that the distribution loss figures are abnormally high in many places in the country and the voltage levels are poor To assess the status(losses and voltages) of distribution systems TERI has taken an ambitious programme of energy auditing of 11 kV primary distribution systems(also for LT systems) The programme would yield the following benefits

(a) Collection of System data through actual field measurements
(b) Plugging the technical and non technical losses and voltage drops
(c) System Analysis and rationalisation
(d) Proposals for implementation of improvement measures with techno-economics

The above auditing can be taken up substation wise, to cover all the feeders or on any specific feeder of interest The measurements and analysis will be carried out with sophisticated hardware and software tools

We request you to make use of the above facility for your utility systems and send us the filled-up questionnaire to enable us to conduct a scoping study at the earliest

Thanking You,

Yours faithfully,

H.V.DAYAL

Tata Energy Research Institute

Energy Auditing of Electrical Power Distribution Systems

Questionnaire:

1 Location name:

2 Substation

- a Capacity (MVA)
- b No Of feeders
- c Voltage levels
- d No of HT consumers
  No of LT Consumers
- e No of Irrigation Pumpsets (if any)

3 Type of system
rural/urban/mixed etc

Peak Load (feeder wise)

5 System scaled map available
Yes/No

6 Load factor

7 Diversity factor

8 Specific problems faced if any

9 Any other comments